the knowledge that enables us to anticipate the rise and fall of the ocean? How are the tidal tables of the daily papers and of 'The Farmers' Almanac' constructed?

It was the primary object of the lectures of Professor Darwin to answer such questions; to explain in a popular way, without the aid of mathematical and physical technicalities, how, from observations of the tides and from the modern theory thereof, predictions of the rise and fall of the ocean at any port may be issued years in advance. In addition to these more obvious tidal phenomena he has also discussed the more recondite phenomena of bodily tides in the earth and other members of the solar system. Thus, from questions of commercial or otherwise purely practical significance, the reader is led up to questions in cosmology of the highest scientific importance, especially in their bearings on the remote history, past and future, of our planet.

The task which Professor Darwin set for himself was a difficult one. Few, if any, questions in the mathematico-physical sciences are more profoundly complicated than those presented by tidal phenomena. Their elucidation has taxed the ingenuity of the most laborious investigators from the time of Newton to the present day. In the highly condensed language of mechanics it may be said that these phenomena, in any case, are simply the outcome of the energy, the angular momentum and the friction involved. But to turn conclusions expressed in such language into common parlance would seem to be almost as great a work as that of reaching the conclusions themselves. No one less well equipped than Professor Darwin would have dared to undertake this task. Thoroughly familiar with the details of tidal action, and himself a principal contributor to recent advances in tidal theories, he has produced a charmingly interesting and instructive book, which may be read with profit by those who know much as well as by those who know little of the tides.

The book is divided into twenty chapters under the following titles: Tides and Methods of Observation, Seiches in Lakes, Tides in Rivers—Tide Mills, Historical Sketch, Tide-generating Force, Deflection of the Vertical, The Elastic Distortion of the Earth's Surface by varying Loads, Equilibrium Theory of Tides, Dynamical Theory of the Tide Wave, Tides in Lakes—Cotidal Chart, Harmonic Analysis of the Tide, Reduction of Tidal Observations, Tide Tables, The Degree of Accuracy of Tidal Prediction, Chandler's Nutation—The Rigidity of the Earth, Tidal Friction, Tidal Friction (continued), The Figures of Equilibrium of a Rotating Mass of Liquid, The Evolution of Celestial Systems, Saturn's Rings. Each chapter is followed by a list of authorities on the subject of the chapter, and a good index completes the volume.

R. S. W.

The Elements of Physics. By ALFRED PAYSON GAGE. Boston, Ginn & Co. 1898. 12mo. Pp. x+381.

The author of this book put forth his first edition sixteen years ago and has long been favorably known as a reliable authority in the school room. The motto then adopted, 'Read Nature in the Language of Experiment,' is very properly retained in the present volume, which is not a revision, but a new book differing quite radically from the first in its method of presentation. The change, moreover, is a great improvement. We all agree that the experimental method is the proper method of investigating what is collectively called Nature, but there has been much difference of opinion about the advisability of regarding elementary pupils in the high school as fit to acquire their fundamental conceptions of physics by independent discovery. In the preface to the present volume Dr. Gage repeats the expression of his belief in the importance of the laboratory method in the high school, but adds that he has 'observed the development of a tendency which threatens seriously to impair its usefulness.' He is now 'convinced that both mental discipline and the acquisition of knowledge will be promoted if theory and experiment be somewhat sharply divided.'

There are a good many of us who have long held this last view in opposition to that which was carried out in Dr. Gage's first book. The demand for laboratory methods in the school room is much more than sixteen years old. A protest against the abuse of them was distinctly

formulated by Dr. Mendenhall in his vice-presidential address delivered before the Section of Physics at the Montreal meeting of the American Association for the Advancement of Science in 1882, the very year when Dr. Gage's book appeared. It is probably safe to say that a majority of American teachers of physics are now agreed in the view that the elementary pupil should not enter the laboratory as an original investigator, because he is utterly unfit to be such until after much training has been received. What he needs is a well arranged, clear and accurate presentation of principles, with such experimental demonstrations by the teacher as may be needed to ensure the acquisition of the truth. After a good introduction has thus been received he should have the opportunity to make a selected series of tests of these principles in the laboratory, and advantage should be taken of such practice to train him into habits of close observation, system, neatness and good order. He needs, therefore: first, a reliable class text-book, the study of which should accompany the teacher's lectures; and, second, a separate laboratory manual, or its equivalent in the form of special written or printed instruction cards adapted to the particular apparatus that is put into his hands after the requisite class-room preparation has been secured. Should he in time manifest enough originality to become an investigator, his work will probably be amid surroundings better adapted for research than the school laboratory.

It is to meet the first of these needs, a reliable class text-book, that the present volume has been written. The author exhibits good judgment, not only in the selection of what he includes, but in omitting certain special topics, such as the polarization of light, of which a smattering is often unwisely given. Such subjects as absorption, osmose and crystallization belong now to the newly differentiated science of physical chemistry. Nevertheless, there remain some embarrassments due to the necessity to avoid mathematics, and the attempt to be a trifle too conservative by recognizing certain details of nomenclature that are deservedly passing away. For example, the poundal is recognized as a unit of force. The only excuse for the invention of such a unit has been to bring the clumsy 'British' system into accordance with the far simpler system, employed by all physicists irrespective of nationalty, that for the sake of contrast is often called the absolute system. Engineers in England and America express weights in pounds, but they have no use for poundals in either theory or practice. The physicist thinks in the simpler system, but often has to translate his final results into the British system. There is hence no use in befogging the minds of young pupils with more than one unit of force, the dyne. Nor is any advantage to be derived from specifying two methods of measuring force, calling one the statical or gravitational system, and the other the dynamical or absolute system. The latter is the only one needed; the former is always expressible in terms of the absolute system. The suggestion of duality is confusing and often misleading. The confusion culminates where the pupil is confronted with poundal, foot-poundal, pound, foot-pound, dyne, erg, gram, gram-centimeter and kilogram, all grouped in a single diagram (p. 71) for the purpose of contrasting the units of force and of work. If all calculations are made in terms of centimeters and grams there is but little trouble in translating final results if necessary.

The author in similar manner speaks of density, specific density and specific gravity. Of these three terms the first is the only one that is really needful, though it may sometimes be convenient to employ the term specific gravity, or relative density, to denote that a secondary rather than primary standard is employed. The distinction between specific density and specific gravity is, of course, definable, but in the interest of simplicity it is not desirable.

In illustrating any subject with numerical examples it is best to employ such as are approximately within the range of practice. After a good description of Joule's apparatus for the determination of the mechanical equivalent of heat, which was operated in Joule's laboratory, an example is given in which the weights are supposed to be raised to a height exceeding that of an ordinary church steeple. There is, of course, no theoretical objection to this. But it is practically of some importance that the final

result should be given in the corrected form which was accepted by Joule after Rowland's exhaustive experiments in Baltimore. Joule's equivalent is now quite generally quoted as 427 rather than 424 kilogram-meters at ordinary laboratory temperature.

The difficulty of conveying clear ideas without mathematical methods is particularly felt in the attempt to define elasticity and to employ this word intelligibly in the formula for the velocity of propagation of a wave. To say that this velocity varies as the square root of the quotient of elasticity by density conveys no idea, unless modulus of elasticity has been previously defined and abundantly illustrated. The ordinary student regards india-rubber, a highly compressible solid, as the type of elasticity, while in reality its modulus of elasticity is exceptionally small. The stretch modulus is defined in an appendix to the present volume; but it is not concerned in the propagation of a sound wave through air, and it is in this connection that the formula is given. To account for the high velocity of sound in solids and liquids by reference to their superior incompressibility is inadequate unless the relation between compressibility and the volume modulus of elasticity has been already made plain. The elementary student has scarcely any alternative but to memorize words in this connection, and to trust to the future for the ideas they are intended to convey, however faithful the author of the text-book may have been to put into English what is always beyond the youthful reader.

The presentation of the subject of electric potential is unusually well given; it is, indeed, as good as could possibly be expected without mathematics. The general treatment of electricity is clear and up to date, several pages being devoted to X-rays and the phenomena of alternating currents of high potential and high frequency.

The book is not free from typographical errors, but these are in no case serious. There are occasional statements of minor importance to which exception may be taken, but the author is generally accurate and reliable, and his skill in the art of presentation is unquestioned. Among the welcome features are woodcut reproductions of the portraits of Archimedes, Galileo, Newton, Franklin, Faraday and Lord Kelvin.

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Leçons de chimie physique. Professées a L'Université de Berlin. Par J. H. VAN'T HOFF, Membre dè l'Académie des Sciences de Berlin, Professeur ordinaire a L'Université, et Directeur de L'institut de Physique de Charlottenburg. Translated from the German by M. CORVISY, Professeur agrégé au Lycée de Saint-Omer. Première partie. *La Dynamique Chimique.* Librairie Scientifique. Paris, A. Hermann. 1898.

This work, as the title implies, is a translation of Van't Hoff's 'Vorlesungen über theoretische und physikalishe Chemie,' or of that part of it which has thus far appeared—Chemical Dynamics. The book, as the author states, "is based upon the lectures which I give at the University of Berlin, on 'Selected Chapters in Physical Chemistry.' Indeed, it contains more than these lectures, since, in the limited time at my disposal, I was able to take up only some of the more important points, in order to cover the entire field in one lecture a week during four semesters." The method of treatment is that adopted by Lothar Meyer in the later editions of his 'Modern Theories of Chemistry.' The whole subject is treated under the general heads of Statics and Dynamics; Statics dealing with homogeneous substances, with views as to the structure of matter, with the molecular and atomic conception, and with the determination of constitution; Dynamics, with the reciprocal transformation of several substances, with affinity, reaction, velocity and chemical equilibrium. A third part is added, on the relation between physical and chemical properties and composition.

The order is, however, reversed. Chemical Dynamics, having been placed on a surer basis by thermodynamics, has acquired greater prominence, and is dealt with at the beginning. We have then: First, *Chemical Dynamics;* second, *Chemical Statics*, and third, *Relations between Properties and Composition.*

The advantage of this order is that in the first part of the work only the molecular conception enters, while the atomic hypothesis and the problem of configuration do not appear